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The effect of lexical constraints on spontaneous stuttered speech

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Abstract

In earlier research with stutterers it appeared that syntactic planning is reflected in the pattern of stuttering: in spontaneous speech there are more stuttered function words than in read-out speech and their frequency is higher in the beginning of a clause than at the end. The aim of the present research is to investigate by means of varying lexical constraints, whether stuttering can also reflect the effort needed for lexical processes in sentence planning. Ten stutterers were asked to describe 14 series of three pictures, with a few written lexical words in each picture. The task was to use these words in the utterance. It appeared that in this task (experimental condition) the frequency of stuttered words is higher than in speech based on pictures without words, normal spontaneous speech and read-out speech (control conditions). It was observed that in the experimental condition more stuttered lexical words occurred at the beginning of a clause than at the end. Therefore, we conclude that in active speech production not only syntactic structures but also lexical items can be planned in a unit ('lexical planning unit') as large as a clause. It is assumed that freedom of word-choice is related to the pattern of stuttering and that a limitation of this freedom can increase the frequency of stuttering.

Keywords: stuttering, spontaneous speech, lexical constraints

Introduction

Earlier research

The experiment described here is part of a series of investigations into the relation between speech planning and the occurrence of stuttering in read-out and spontaneous speech of adult stutterers. From this research it appears that the distribution of stuttering frequencies over word positions in clauses is different for spontaneous and read-out speech. Stuttering on function words is more frequent in spontaneous speech than in read-out speech; function words are articles, pronouns, conjunctions and prepositions and have a grammatical function (Soderberg, 1967; Crystal, 1980). Moreover, in spontaneous speech stuttering occurs relatively more frequently on function words at the beginning of clauses than at other positions of the clause (Koopmans, Slis and Rietveld, 1992). Based on the assumption of Starkweather (1987) this difference in stuttering patterns in spontaneous versus read-out speech may be explained in terms of presumed differences in (over)load on the underlying processes of speech production. Starkweather supposes that demands (e.g. the use of syntax, correct pronunciation, environmental demands, etc.), and capacities (e.g.

the skill to structure a message or to find the right word, etc.), guide the development of fluent speech production. In a situation in which demands exceed the overall capacity, overload and therefore stuttering may occur. Overload due to syntactic demands is liable to occur at clause boundaries where a whole syntactic unit has to be programmed. Overload due to informational or emotional demands may occur at the onset of words within a clause with a high informational or emotional load.

Levelt (1989) states that in spontaneous speech the translation of an intention into a linguistic structure is a controlled aspect of the spontaneous speech process. A controlled process is a conscious process, with an intention and a specific amount of load on the processing capacity. In such a process consciously applied strategies are employed (Shiffrin and Schneider, 1977). In contrast, an automatic process takes place unconsciously, without intention, and with relatively little processing effort. Further processing of the linguistic structure, which is formed on the basis of an intention, involves the formulator and articulator and is automatic, according to Levelt. Nevertheless, from time to time a conscious evaluation of the resulting speech product takes place with the assistance of the monitor.

On the other hand, when reading out a text the translation of an intention into a linguistic structure is absent. Reading out a text may be viewed as an automatic process requiring relatively little processing effort (Bock, 1982). The fact that, on average, stuttering occurs more often in spontaneous speech than in read-out speech (Koopmans *et al.*, 1992) indicates a possible connection between the amount of conscious control during the speech process and the amount of stuttering.

Koopmans *et al.* (1992) assumed a difference in syntactic activity between spontaneous and read-out speech and viewed the above-mentioned difference in the relative frequency of stuttered function words between the two types of speech as empirical support for this assumption. In spontaneous speech a syntactic structure has to be formed. This requires more effort than does the syntactic process in reading out speech, where the syntactic structure is already given. Since the percentage of stuttered function words is higher at the beginning than at the end of clauses, it is likely that the syntactic activity in spontaneous speech is higher at the beginning of clauses. Therefore, we may assume that it is mostly at the beginning of a clause that its syntactic structure is established. In contrast with read-out speech, the syntactic structure in spontaneous speech is not laid down in advance but has to be created. This gives rise to a relatively high load on the syntactic process at the beginning of clauses.

It appeared that the stuttering pattern on content words showed hardly any difference for the two types of speech (Koopmans *et al.*, 1992); content words are nouns, adjectives, adverbs and verbs (Crystal, 1980). A number of explanations may be given for this observation. In contrast to read-out speech, in spontaneous speech the content and the related words are speaker-chosen. If we assume that, apart from choosing the content, the choice of the related words is also a controlled process, the searching for words involves relatively much effort. However, at the same time the speaker has the possibility to choose the words in such a way that the load on the lexical process is minimal, both on the semantic and on the articulatory level. By example, the speaker may choose to say 'I will set the table' instead of 'I will put everything that we need for the meal on the table so that it is possible to start eating'. The latter formulation is more complex than the first and asks probably more processing effort. Therefore, in spontaneous speech choosing content words entails a loading (to make a choice) as well as a facilitating (to choose easy words)

component, the two of which may well be compensatory. Since in read-out speech the semantic content is already-given information, the process of speech production is not loaded by the searching for content words. On the other hand, a free choice of the words is not possible. Because the possibility to avoid given (and hence not self-chosen) words that are relatively hard to pronounce is absent, this restraint may result in an added load. Presumably, this added load mainly bears on the articulation process because, as motivated above, the semantic and syntactic processes in read-out speech require little processing effort.

So, for the production of content words, both types of speech call on the available energy in a different manner and to a different degree. Focusing solely on the observed frequencies for stuttered content words, it would appear that the lexical processes in both types of speech lead to an equal amount of overload but, in view of the difference in the nature of the lexical processes for the two types of speech, not for the same reasons. Therefore, the difference between the underlying lexical processes in spontaneous versus read-out speech does not show up in the amount of stuttered content words. It can even be questioned whether the amount of activity of the lexical processes is indeed reflected in the number of stuttered content words.

In order to gain more insight into this question we conducted an experiment with a third type of speech differing from both spontaneous and read-out speech as to the amount of activity in the underlying lexical processes. In this type of speech we expect this difference to show up in a stuttering pattern for content words differing from the patterns for both spontaneous and read-out speech.

Research into lexical constraints

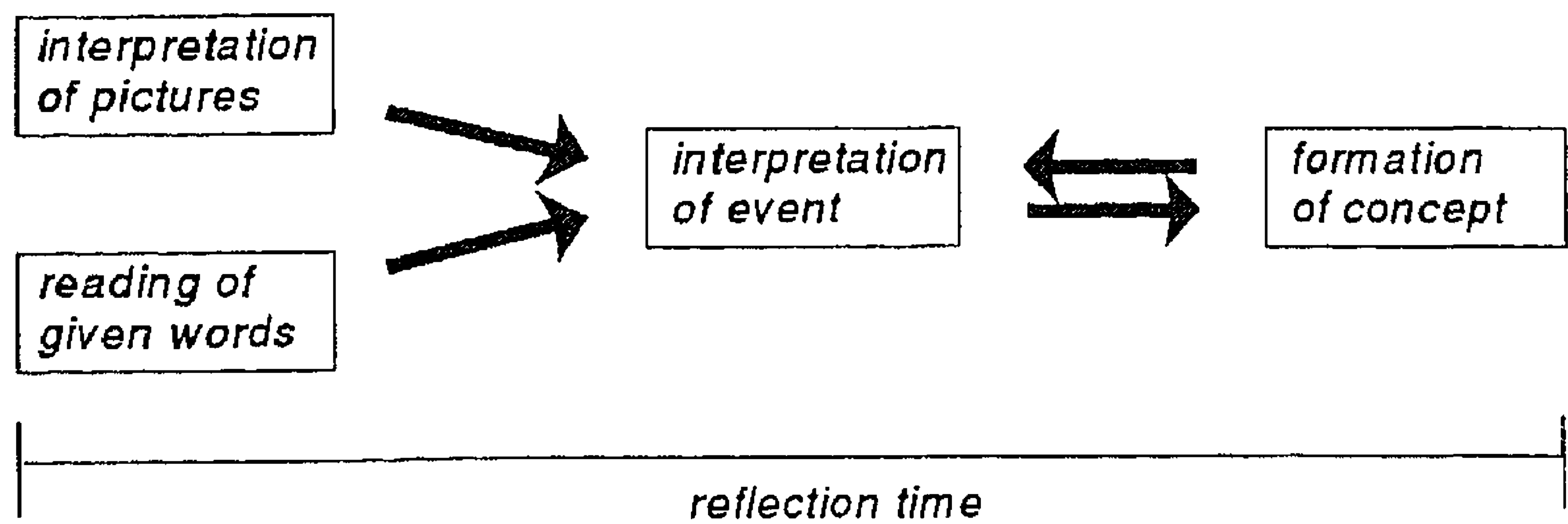
The speech to be investigated is a type of spontaneous speech elicited under two constraints:

1. a conceptual constraint: subjects were asked to verbally describe a series of three pictures that formed a short story;
2. a lexical constraint: in verbally describing the series of three pictures, subjects were asked to use the words given in the pictures.

The process is schematically depicted in Figure 1. In the reflection time (phase A), before speech production takes place, subjects read the compulsory content words and interpret the pictures; then an interpretation of the event as a whole is made and a concept is formed. During the following speech production phase (phase B) this concept has to be translated into speech: based on the formed concept and the given words a semantic structure with lexical concepts is made; then the formation of the syntactic structure takes place and words are inserted.

First, we will briefly address the lexical process itself, concentrating on the possible effects we may expect it to have in the experimental task. We assume the lexical process to consist of two subprocesses: one in which information concerning lemmata is put in the correct order, and one in which the related phonological representations are inferred from the lemmata information. It is not yet clear how exactly these processes interact. It is possible that each lemma that is activated is translated immediately into a phonological representation. On the other hand, it may be that several lemmata are stored in a buffer and are encoded in a phonological structure only later (Dell and O'Seaghdha, 1992). Spontaneous speech allows for a last-moment planning of the exact phonological form of the lexical concept, just

Phase A



Phase B

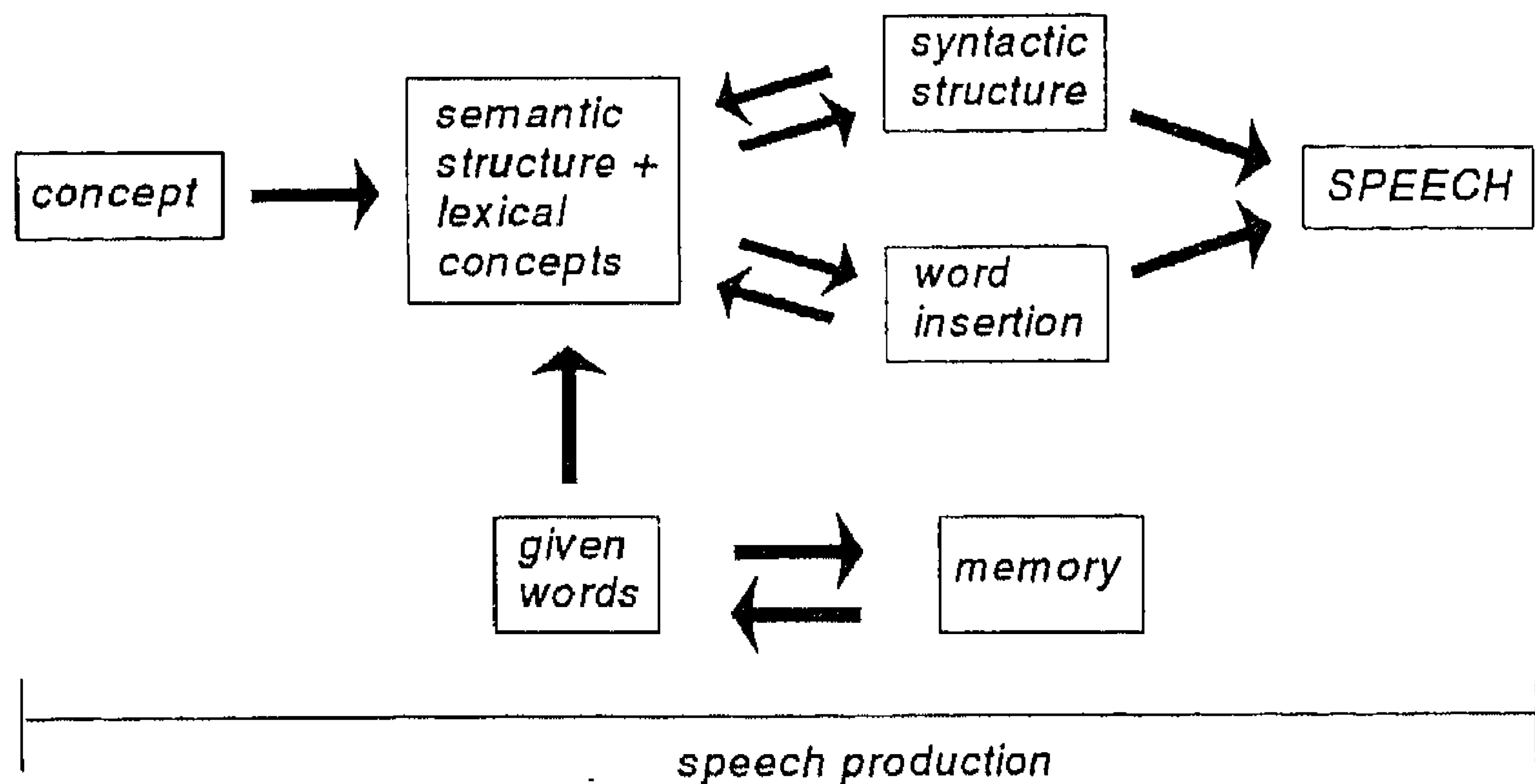


Figure 1. *Schematic representation of the various processes during reflection (phase A) and speech production (phase B) in the experimental task [P +].*

before articulation. If this is the case, the ‘unit of lexical planning’ is one word. However, this does not exclude the possibility that lexical items are planned across larger units than just one word. With regard to the ultimate processes that play a part in structuring the utterance under the influence of lexical constraints, we pose the following two explanations, which lead to different, opposite results.

According to Bock (1982) it is likely that lexical information given in advance hardly loads, but rather facilitates, the production of sentences. The compulsory words in the experimental task will, as such, hardly load the speech process, because they have been read prior to speaking and because they can be read again during speaking. For that matter, reading is an automatic process hardly interfering at all with other processes (Bock, 1982). So, our first contention is that reading content words facilitates the speech process. This also implies a facilitation of the lexical process. If an interaction between lexical and syntactic processes takes place, the syntactic process is also facilitated. The fact that for the remaining content words the choice is from a smaller sample of lemmata would then result in a lower number of stuttered content words.

However, an opposite view is tenable. The compulsoriness of certain words crucial to the content imposes certain restrictions on the speaker. These constraints on the free choice of the other content words may well lead to added processing effort, for example because the compulsory use of given words restricts the possibility of choosing words that are more facile, with regard either to content and/or to

articulation. Moreover, the compulsory content words force the speaker to find a fitting syntactic structure, which should also allow for the other, self-chosen content words. Therefore, it may well be that the insertion of lemmata for both the compulsory and the self-chosen content words for the part of the sentence being planned takes place at the beginning of the syntactic planning unit. If this is the case, the lexical process, and perhaps even the syntactic one, is more heavily loaded at the beginning of clauses; the compulsory content words would then interfere with the speech process. Just as a relatively high syntactic activity is deduced from a relatively high percentage of stuttered function words (Koopmans *et al.*, 1992), this heightened lexical activity at the beginning of clauses would show up in a relatively high percentage of stuttered content words at the beginning of clauses. Since the compulsory content words need already to be taken into account at the moment of formulating the sentence, we assume that the load on memory for these compulsory content words is higher than that for the content words that are to be chosen freely. In short, in this explanation the inclusion of compulsory content words in a sentence is controlled rather than automatic, and thus gives rise to a relatively high load on the underlying process.

This second explanation, which we think more likely, is taken as a basis for formulating the hypotheses given below:

- (a) Speech on the basis of pictures with lexical constraints requires a higher activity for the lexical processes than speech on the basis of pictures without lexical constraints; this holds for both normal spontaneous and read-out speech. In the experimental condition we expect more stuttering on the content words than in the control conditions.
- (b) Syntactic processes, too, are more heavily loaded in the experimental condition than in both control conditions. Therefore, more stuttering on function words will occur in speech on the basis of pictures with lexical constraints than in the control conditions.
- (c) In speech on the basis of pictures with lexical constraints more stuttering on content words is expected at the beginning of clauses than at the end of clauses. For the control conditions no difference is expected.
- (d) In speech on the basis of pictures with lexical constraints more memory effort is required for the given words than for self-chosen words. This will result in more stuttering on given than on self-chosen words.

Method

Subjects

Ten Dutch adult stutterers (one female, nine male) participated in the experiment with the lexical constraints condition [P +]. All had received stuttering therapy. The same 10 subjects participated in a second experiment with the three control conditions: speech based on the same pictures without words [P –], normal spontaneous speech [NS], and read-out speech [R +] on the basis of a text obtained in the earlier experiment with the [P +] condition. The experiment was conducted in the Dutch language.

Material and conditions

P + : Speech on the basis of pictures with words. The speech was elicited by means of 14 series of three pictures each. Each series depicted a story with an unambiguous ending. Each picture contained a few (one to four) content words. The given words were all frequent ones. On average, these words could not be regarded as phonetically complicated. Figure 2 gives two of the 14 series of pictures.

P – : Speech on the basis of pictures without words. The same series of pictures as in the experimental condition were employed to elicit the speech. However, no words were given here.

NS: Normal spontaneous speech. The speech was elicited by posing statements on which the subjects were asked to comment (interview) (Koopmans, Slis and Rietveld, 1991a, 1992).

R + : Read-out speech. The text elicited in the experimental condition [P +] was read out by the same subjects about half a year later.

Procedure

P + : Speech on the basis of pictures with lexical constraints

Each of the subjects was asked to give a verbal description of the 14 stories of three pictures each. In their descriptions the subjects had to use all the given content

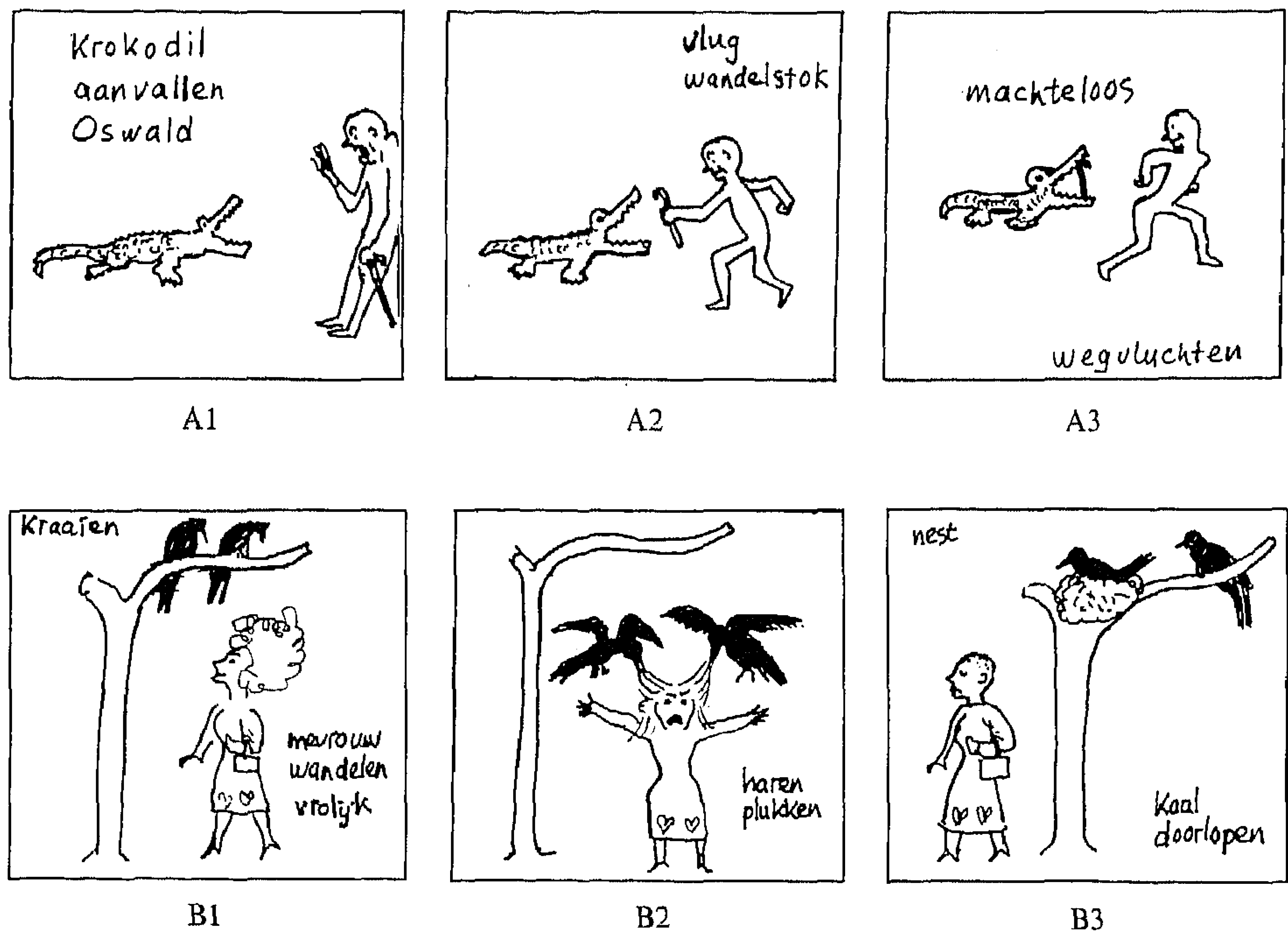


Figure 2. Two examples of pictures with compulsory words as used in the [P +] condition. English translation of the given words as follows. A1: crocodile, attack, Oswald; A2: fast, walking stick; A3: helpless, run away. B1: crows, lady, walk, happy; B2: hair, pick; B3: nest, bald, walk on.

words. Conjugations and declensions of the given words were permitted. Subjects were given ample time to reflect before giving their description of each event. The pictures with the given words remained available throughout the task. In this manner we tried to obtain speech in which the subjects embedded all the words given by the experimenter in natural-sounding spontaneous speech.

For each subject, the first two of the 14 events described were regarded as practising material. In order to keep the variability in the characteristics of the stimulus material as low as possible, we only took those series into further consideration that had been interpreted in the same way by all subjects, and that had elicited natural sounding spontaneous speech. From these we randomly selected five stories. The descriptions for these five events supplied us with a representative amount of material for our analysis (a total of 1793 words, 842 content words and 951 function words). Subsequently, the selected material was written out as literally as possible (transcription).

P – : Speech on the basis of pictures without lexical constraints

In this experiment, which took place about half a year later, we employed the same procedure as in the [P +] experiment, employing the same pictures, this time, however, without the compulsory content words. During the 6 months between the [P +] and [P –] conditions the subjects did not have any treatment.

NS: Normal spontaneous speech

Spontaneous speech samples were obtained in an interview setting. All subjects were asked to give their opinion on a number of statements, among other things with regard to eating habits, e.g. '*What is nice is good for your health*'. The spontaneous speech thus obtained consisted primarily of simple sentences containing one clause and complex sentences containing several clauses. The normal spontaneous speech used in this experiment was in fact obtained in an earlier experiment with 25 subjects (Koopmans *et al.*, 1992). Of course, we only selected the speech of those subjects that also participated in the two conditions mentioned above, [P +] and [P –].

R + : Speech on the basis of the read-out text from the [P +] condition

About half a year after the [P +] experiment, we asked our subjects to read out the text elicited for the five series of pictures selected from the experiment with pictures and lexical constraints [P +]. All sentences were edited to obtain a natural, readable version, i.e. without any disfluencies. Each subject read out his own text, the one he had spontaneously produced in the earlier experiment. All texts were coherent as to contents. This condition was included in order to ensure that the effects observed are not attributable to the phonetic characteristics of the given words.

Data analysis

The transliterations of the descriptions for the five selected series of pictures were broken down into clauses. A clause was defined as a group of words belonging together on the basis of grammatical, prosodic or conceptual relations. We confined ourselves to the formal criterion that a clause should minimally contain a subject

(NP) and a predicate (VP). This criterion concurs with the definitions of ‘surface clause’ (Fodor, Bever and Garrett, 1974) and ‘full finite clause’ (Ford and Holmes, 1978; Ford, 1982), see Example 1.

Example 1

Wat	het	eten	betreft	ben	ik	. . .	
F	F	C	C	C	F		
Beginning		End		Beginning			(Word positions)

Within each clause we distinguished two word positions:

Beginning: the first and second word of the clause;

End: the remaining words of the clause.

Each word was labelled as to word type:

F: function word;

C: content word.

Function words are prepositions, pronouns, conjunctions, and articles. These are important elements for the structuring of the clause and, as such, their function is a grammatical one (Soderberg, 1967; Crystal, 1980). Content words are nouns, verbs, adjectives, and so on (Crystal, 1980). See example 1 of a clause with word types and word positions.

In the experiment on lexical constraints we distinguished the following content words:

G: compulsory *given* content words;

F: *freely* chosen content words.

To classify types of disfluencies we used the categorization method of Franken (1985). We scored phoneme-repetitions, syllable-repetitions, word-repetitions, prolongations and blocks. Interjections were discarded. We counted the number of stuttered words per speech type, word position, and word type. A summation over our 10 subjects gave the total number of stuttered words.

Results

In order to assess to which degree the judgements of the experimenter were idiosyncratic, her scores were compared with those of a speech therapist not involved in the experiments, but trained in the use of the criteria applied here. The experimenter and the speech therapist scored stuttering with the criteria of Franken (1985) in a sample of 387 words of spontaneous speech. In this type of speech we expected all difficult cases to occur, due to possible confusion between stuttering and normal hesitation. Thus the agreement in scoring obtained in spontaneous speech could be regarded as a representative level of agreement for the whole material. All words of the sample scored by the two judges were labelled as either stuttered (+) or non-stuttered (–). The agreement was very high: Cohen’s kappa=0.937, z=9.314, p<0.01.

As the data were counts of stuttered words, they were analysed by means of a number of loglinear analyses (Rietveld and van Hout, 1993), with the logits of the frequencies of stuttered words ($\ln(F_i/F_j)$) as dependent variables. This type of

analysis consists in finding the most parsimonious model—in terms of independent variables—that accounts for the observed logs of the ratios of frequencies of stuttered and non-stuttered words.

Each analysis was based on saturated models and tested the independent variables *speech* (speech on the basis of pictures with lexical constraints [P +], speech on the basis of pictures without lexical constraints [P –], normal spontaneous speech [NS], and read-out speech [R +]), *word position* (beginning or end of the clause), and *word type* (content word) [C] versus function word [F]). The [P +] condition contained the additional independent variable of *choice* (compulsory given [G] versus freely chosen [F] content word).

General analyses

A comparison of the three types of spontaneous speech ([P +], [P –], and [NS]) within a single analysis gives a significant three-way interaction of *speech* \times *word position* \times *word type* ($z = -3.547$, $p < 0.05$). Apparently, a combination of these factors plays a role in the explanation of our data. So, to assess their specific effects we investigated the differences between the three types of spontaneous speech in pairwise comparisons. For the variables *word position* and *word type* no significant differences were observed between the two control conditions [P –] and [NS]. However, we found a significant difference for these two variables between the experimental condition [P +] and the control condition [P –]. It appears that stuttering occurs more often in the [P +] condition (22.1%) compared to the [P –] condition (14.5%, *speech*: $z = 5.770$, $p < 0.05$) as well as compared to the [NS] condition (14.4%, see Figure 3a). A comparison of the [P +] and [P –] conditions also showed a significant three-way interaction of *speech* \times *word position* \times *word type* ($z = -1.978$, $p < 0.05$).

These results support the assumption that the factors *word position* and *word type* contribute significantly towards the difference between the [P +] and [P –] conditions. Although we did not counterbalance the [P +] and [P –] conditions, we assume that it is not very plausible that the difference between these two conditions is attributed to intervening variables because: (a) the [P –] condition did not differ from the [NS] condition and (b) the subjects did not have any treatment between the conditions [P –] and [P +].

The next stage is to test the main effects with regard to our hypotheses.

Hypothesis (a)

A comparison of the scores on content words in the [P +] experimental condition and the [P –] control condition with regard to the independent variables *speech* and *word position* shows a higher stuttering rate for the [P +] condition (23.5% vs 17.5%). The factor *speech* is significant, $z = 3.155$, $p < 0.05$ (Table 2a). For both control conditions ([P –] and [NS]) we observe no significant difference in the stuttering rate for content words (17.5% vs 14.6%). It also appears that stuttering on content words in the [P +] condition occurs more often at the beginning than at the end of clauses (29.1% vs 21.4%): the factor *word position* is significant, $z = 2.302$, $p < 0.05$ (Table 2a; see also hypothesis (c)). This observation is in accordance both with hypothesis (a), which states that stuttering will occur more frequently in

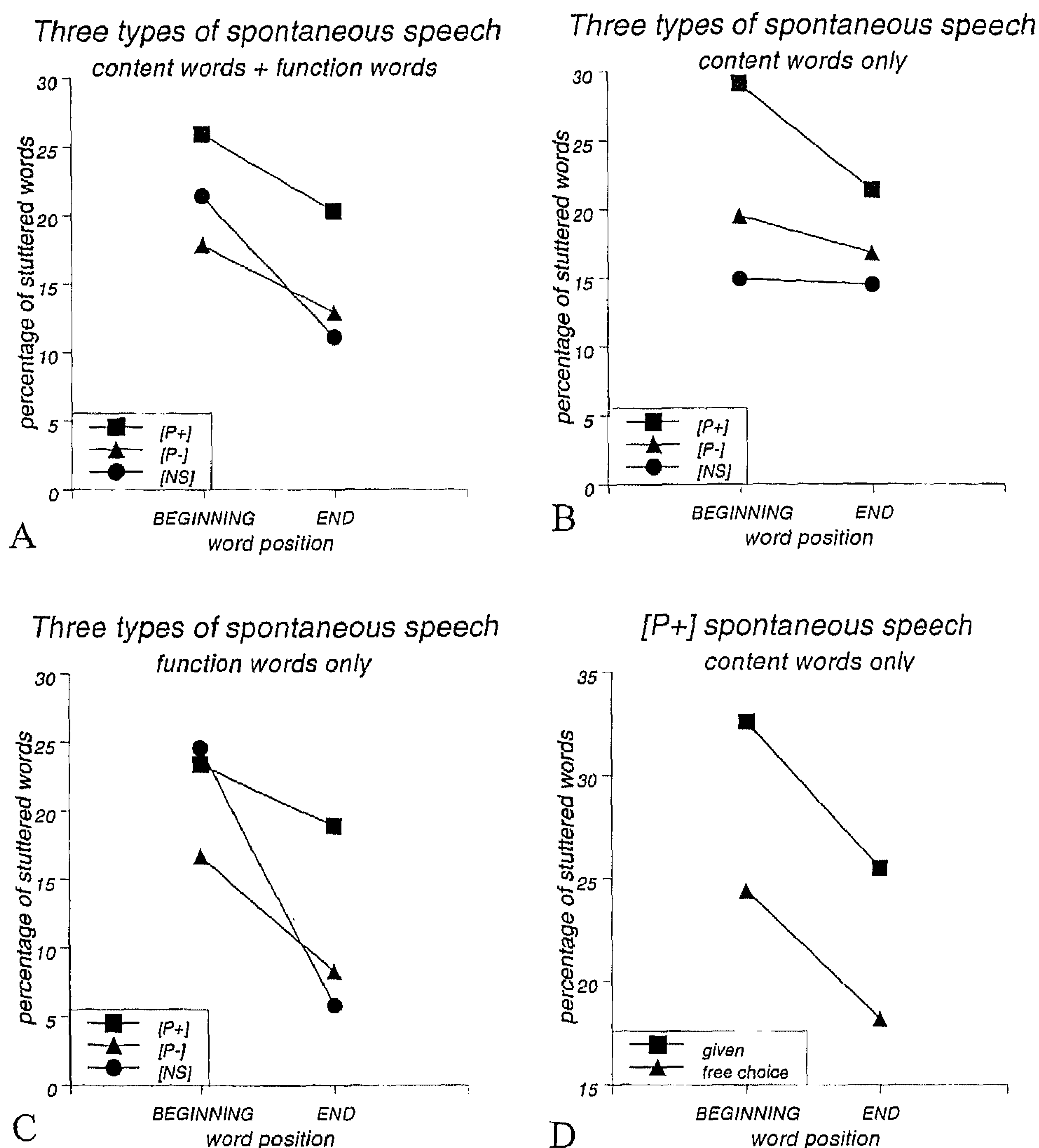


Figure 3. Graphic representations of percentages of stuttered words in spontaneous speech. A: Total percentages of stuttered words for three types of spontaneous speech, the [P +], [P -], and [NS] conditions; B: Percentages of stuttered content words for three types of spontaneous speech, the [P +], [P -], and [NS] conditions. C: Percentages of stuttered function words for three types of spontaneous speech, the [P +], [P -], and [NS] conditions. D: Percentages of stuttered given (G) and freely chosen (F) content words in the experimental condition [P +].

the [P +] condition than in the control conditions, and with hypothesis (c), which predicts an effect for *word position* on content words in the [P +] condition.

Hypothesis (b)

A similar pairwise comparison for function words shows that stuttering on function words occurs more in the [P +] condition than in the [P -] condition (20.5% vs 11.4%). The factor *speech* is significant, $z = 4.963$, $p < 0.05$ (Table 2b). Also, we

Table 1a. Absolute numbers of stuttered (+st) and non-stuttered (–st) words, as well as percentage of stuttered words (%+st), for content [C] and function [F] words at the beginning and end of clauses, separately for the [P+], [P–], [NS], and [R+] conditions

	Beginning			End			Total		
	F	C	tot	F	C	tot	F	C	F + C
[P+] Speech for pictures with words									
+st	73	72	145	100	151	251	173	223	396
–st	239	175	414	430	553	983	669	728	1397
%	23.4	29.1	25.9	18.9	21.4	20.3	20.5	23.5	22.1
[P–] Speech for pictures without words									
+st	56	43	99	47	112	159	103	155	258
–st	279	177	456	518	552	1070	797	729	1526
%	16.7	19.5	17.8	8.3	16.8	12.9	11.4	17.5	14.5
[NS] Normal spontaneous speech									
+st	57	17	74	17	64	81	74	81	155
–st	175	97	272	274	377	651	449	474	923
%	24.6	14.9	21.4	5.8	14.5	11.1	14.2	14.6	14.4
[R+] Read-out speech									
+st	24	44	68	39	87	126	63	131	194
–st	288	203	491	491	617	1108	779	820	1599
%	7.7	17.8	12.2	7.4	12.4	10.2	7.7	13.8	10.8

Table 1b. Absolute numbers of stuttered (+st) and non-stuttered (–st) words, as well as percentage of stuttered words (%+st), for compulsory given [G] and freely chosen [F] content words at the beginning and end of clauses, for the [P+] condition

	Beginning		End		Total		
	G	F	G	F	G	F	G + F
+st	42	30	80	71	122	101	233
–st	87	88	234	319	321	407	728
%	32.6	24.4	25.5	18.2	27.5	19.9	23.5

Table 2a. A comparison between the [P+] and [P–] conditions for content words

	Coefficient	z-Value
Freq	–0.647	–19.970*
Freq × Word position	0.074	2.302*
Freq × Speech	0.102	3.155*
Freq × Word position × Speech	0.028	0.873

*Significant at the 5% level.

Table 2b. *A comparison between the [P +] and [P –] conditions for function words*

	Coefficient	z-Value
Freq	–0.828	–24.303*
Freq × Word position	0.133	3.901*
Freq × Speech	0.169	4.963*
Freq × Word position × Speech	–0.065	–1.900

*Significant at the 5% level.

observe no significant difference between the two control conditions as to the stuttering rate on function words (11.4% vs 14.2%).

This result is in accordance with hypothesis (b), which predicts more stuttering on function words in the [P +] condition than in the control conditions.

Hypothesis (c)

For each of the three spontaneous speech types we performed a separate analysis with the factors *word position* and *word type* (Tables 3a, 3b, and 3c). From these analyses it appears that in all three conditions stuttering occurs more frequently at the beginning than at the end of clauses: [P +] 25.9% vs 20.3%, [P –] 17.8% vs 12.9%, [NS] 21.4% vs 11.1% (*word position*: $z_{P+}=2.846$, $z_{P-}=3.379$, $z_{NS}=4.096$, $p<0.05$, Figure 3a).

A remarkable result is that in the [P +] condition stuttering occurs more often

Table 3a. *Analysis of the speech with pictures with lexical constraints [P +]*

	Coefficient	z-Value
Freq	–0.602	–20.005*
Freq × Word position	0.086	2.846*
Freq × Word type	–0.057	–1.896
Freq × Word position × Word type	–0.017	–0.574

Table 3b. *Analysis of the speech with pictures without lexical constraints [P –]*

	Coefficient	z-Value
Freq	–0.873	–24.167*
Freq × Word position	0.122	3.379*
Freq × Word type	–0.124	–3.429*
Freq × Word position × Word type	0.076	2.097*

Table 3c. *Analysis of the normal spontaneous speech [NS]*

	Coefficient	z-Value
Freq	–0.919	–17.864*
Freq × Word position	0.211	4.096*
Freq × Word type	–0.048	–0.933
Freq × Word position × Word type	0.199	3.857*

Table 3d. *Analysis of the read-out speech [R +]*

	Coefficient	z-Value
Freq	-1.058	-25.276*
Freq \times Word position	0.061	1.461
Freq \times Word type	-0.189	-4.519
Freq \times Word position \times Word type	-0.047	-1.131

*Significant at the 5% level.

at the beginning than at the end of clauses for both content words and function words (C: 29.1% vs 21.4%; F: 23.4% vs 18.9%). Indeed, the interaction *word position* \times *word type* is not significant, $z = -0.574$, n.s. On the other hand, in the [P -] and [NS] conditions this difference in stuttering rate at the beginning and end of clauses was only found for function words, but not for content words (see Table 1a). The relevant interaction *word position* \times *word type* was significant, $z_{P-} = 2.097$, $Z_{NS} = 3.857$, $p < 0.05$ (Figures 3b and 3c).

A similar analysis for the [R +] condition (read-out speech) did not show a *word position* effect, neither for content words nor for function words. In the [R +] condition the only effect found was that, on average, stuttering occurred more on content words than on function words, *word type*: $z = -4.519$, $p < 0.05$. This corroborates results from earlier research. We would like to point out that, on average, stuttering is less frequent in the [R +] condition (10.8%) than in any of the three spontaneous speech conditions (22.1%, 14.5%, and 14.4%). The stuttering pattern in the [R +] condition does not deviate from that found in earlier research on any of the factors mentioned.

The fact that in the [P +] condition stuttering on content words is more frequent at the beginning than at the end of clauses, this in contrast with the control conditions, is in accordance with hypothesis (c).

Hypothesis (d)

From a separate analysis of the content words in the [P +] condition (Table 4) it appears that stuttering is more frequent on the compulsory (given) content words (G) than on the freely chosen ones (F), G: 27.5%; F: 19.9%; *choice*: $z = 2.295$, $p < 0.05$, Figure 3d). This result confirms hypothesis (d), which states that compulsory words require a higher load on memory.

Moreover, stuttering on both compulsory and freely chosen content words is more frequent at the beginning than at the end of clauses (G: 32.6% vs 25.5%; F:

Table 4. *Analysis of compulsory (given) and freely chosen content words in the speech with pictures with lexical constraints [P +]*

	Coefficient	z-Value
Freq	-0.544	-12.960*
Freq \times Word position	0.096	2.295*
Freq \times Word position	0.097	2.319*
Freq \times Choice \times Word position	-0.011	-0.252

*Significant at the 5% level.

24.4% vs 18.2%). Indeed, the factors *choice* (compulsory versus freely chosen content words) and *word position* do not interact: *choice* \times *word position*: $z = -0.252$, n.s. This result, too, supports hypothesis (d); it also indicates that the effect of *word position* cannot be attributed to the assumed load on memory.

Discussion and conclusions

The results of the experiment reported here show the effect of lexical constraints on the spontaneous speech of adult stutterers. The most important aspects of the task employed in the [P +] condition were: (a) the elicitation of spontaneous speech using pictures, and (b) the inclusion in the pictures of a few content words that had to be used in the utterance to be produced, together with self-chosen words.

On average, stuttering on both content words and function words occurs more often in speech with pictures with lexical constraints [P +] than in speech on the basis of pictures without lexical constraints [P –] and in normal spontaneous speech [NS]. As we will explain below, this entails a higher degree of control of the speech production process in the [P +] condition than in the [P –] and [NS] conditions.

Starting from the assumption that the amount of stuttered content words gives an indication of the degree to which the lexical process is loaded, we view the relative high frequency of stuttered content words in the [P +] condition as a confirmation of hypothesis (a). This hypothesis states that, for the production of content words, the load on the lexical process is higher in the [P +] condition than in the [P –] and [NS] conditions. Thus, it would appear that the incorporation of given content words in a spontaneous speech utterance specifically loads the lexical process.

Hypothesis (b) assumed that the compulsory use of given words also affects the syntactic process. If our assumption is correct that the amount of stuttered function words is an indication of the load on the syntactic process, this hypothesis, too, is confirmed by our results. The [P +] condition also showed more stuttering on function words than did both control conditions of spontaneous speech ([P –] and [NS]). In short, the lexical as well as the syntactic processes are more heavily loaded in the [P +] condition than in the control conditions ([P –] and [NS]). This result does not support Garrett's (1976) notion that important aspects of the syntactic processes function independently of the semantic content.

The results given above lead to the supposition that the relative contributions of the lexical and syntactic processes to the total degree of load on the system vary as a function of the type of spontaneous speech. Since there is no difference in stuttering frequency between the [P –] and [NS] conditions, we assume that the effects on the lexical and syntactic processes in the [P +] condition result from the lexical constraints imposed.

In contrast to the results for the [P –] and [NS] control conditions, the [P +] condition shows a higher stuttering frequency on content words at the beginning than at the end of clauses. This holds for both compulsory and freely chosen content words. This confirms hypothesis (c), which states that the domain of lexical planning is larger in the experimental condition than in both control conditions. The results indicate a lexical planning domain the size of a clause. In other words, in the [P +] task lexical items are planned in a domain that is larger than one word. This supports recent findings of Dell and O'Seaghdha (1992): the lemmata of a relatively large utterance can be stored in a buffer before specifying them phonologically.

On the basis of these results we assume that spontaneous speech allows for

'word-for-word' planning ([P –] and [NS] conditions) as well as for lexical planning across clauses ([P +] condition).

The finding of a higher stuttering frequency for function words at the beginning of clauses led Koopmans *et al.* (1992) to assume that, in many instances, the domain of syntactic planning has the size of a clause. This is consistent with results from research into pauses (Hawkins, 1971; Goldman-Eisler, 1968; Butterworth, 1980). This characteristic of spontaneous speech finds support in the research reported here, since in all three types of spontaneous speech ([P +], [P –], and [NS]) stuttering on function words is more frequent at the beginning than at the end of clauses. The fact that this effect was observed for all three types of spontaneous speech indicates that the size of the syntactic planning domain is not affected by lexical constraints.

Our results for content and function words taken together lead to the conclusion that planning activity at the beginning of clauses does not solely consist of syntactic processes. The activity of lexical processes may also be higher at the beginning of clauses, as appears from the [P +] condition. In view of the limited capacity of the speech production process as a whole, this would entail more strain on the syntactic process. From this, it seems reasonable to assume, on the basis of our results, that the given content words in the experimental task [P +] do not affect the lexical process and the syntactic process to the same extent. This difference might result from an interaction between the two processes. These results also lead to the assumption that not only syntactic processes, but lexical processes too, may have an independent effect on the stuttering frequency. This is in agreement with Bock's (1982) suggestion that the organization of the speech production system is not strictly hierarchical: syntactic and lexical processes are parallel processes, although interaction is possible.

From our finding that stuttering is more frequent in the [P +] condition than in the [P –] and [NS] conditions it follows that the lexical information the speaker is compelled to use does not have a facilitory effect. This conclusion is supported by the observation that in the [P +] condition the stuttering frequency on content words is higher at the beginning of a clause than in the rest of the clause. This effect of word position is found for both compulsory and freely chosen content words. The fact that the compulsory words are visually available during speech production apparently does not give rise to any facilitation. We therefore assume that it is not just a matter of reading out the compulsory words during speech production. The lexical constraints apparently limit the free choice of other content words. We assume that under the influence of lexical constraints the process of choosing the other words is less automatic than it is in normal spontaneous speech. An increase in the required control will lead to a proportional increase in processing activity, and thus to a possible overload on the process. This entails that less automatic processes lead to more stuttering.

It appeared that, on average, stuttering on compulsory content words is more frequent than on freely chosen content words, which supports the assumption that, apart from the specific linguistic activity, memory activity also loads the total processing activity in speech planning, confirming our hypothesis (d). However, this load on memory is not the same as the general load caused by lexical constraints on content words (and function words), because, just like the compulsory content words, the freely chosen content words (that do not have to be remembered) also give rise to more stuttering in the [P +] condition than do content words in the

[P –] and [NS] control conditions. Moreover, the effect of word position in the [P +] condition is the same for compulsory and freely chosen content words.

Finally, in order to preclude that our results are mainly attributable to phonetic characteristics of the given content words, we included the [R +] condition in our experiment. In this condition the text that was produced in the earlier [P +] condition was read out. We did not find any differences with results from earlier reports on research with read-out speech with a completely different phonetic content. Together with the fact that the given words were on average not phonetically complicated, this leads us to conclude that the phonetic characteristics did not decisively affect our results. This also concurs with the findings by Stemberger (1983) that, in experiments on word substitution, the selection of the other words in the sentence is affected more by the semantic than by the phonological characteristics of the given words.

It would appear that overload of the speech production system is more frequent with stutterers than with normal speakers. The speech production system of stutterers might have less capacity. Thus, more than in normal speakers, the demands made by linguistic factors lead to overload, which in its turn gives rise to stuttering. This assumption is a specification of Starkweather's (1987) hypothesis that stuttering occurs when the capacity of the speech production system is overloaded. Presumably these linguistic loading effects also occur with normal speakers, but rather in the form of lengthening or pauses. It is still not clear at which level of the speech production process the overload that leads to stuttering does occur. Because stutterers produce syntactic and semantic correct sentences the conclusion that stutterers have less capacity than non-stutterers at higher linguistic processing levels—the lexical and syntactic level—is not very plausible. When we assume parallel processing of different levels of the speech production process (Levelt, 1989) it could be that stutterers have less capacity at a lower processing level, e.g. the articulation level.

The results from our research suggest not only that the variation in the amount of syntactic planning is directly related to the occurrence of stuttering, but that such a direct relationship also exists between the variation in the freedom of word choice and the degree to which, and the systematics with which, stuttering occurs. Constraints on the freedom of word choice are a relatively frequent aspect of everyday communicative situations, for example when the speaker uses a foreign language of which his vocabulary is limited, or in those instances where an explanation on a specific subject requires the use of a specialized terminology. In our view it is likely that spontaneous speech is generated employing different strategies in which the nature of the underlying planning processes may differ to a large extent.

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